The Position of the Examiner

With regard to claim 1, the Examiner asserts that the Ito et al. reference discloses a condensate demineralizer for use in demineralizing in a nuclear power plant, comprising a mixed bed of a strongly acidic gel-type cation exchange resin and a uniform particle size strongly basic porous anion exchange resin.

The Examiner relies upon new reference, "DOWEX MARATHON MSA Product Information," and states that DOWEX MSA-l has an average particle size of 500-1000 microns, and a particle size distribution in which 95% or more of resin particles are within the range of the average particle size ± 100 microns.

Applicants' Arguments

Applicants respectfully disagree with the Examiner's position for the following reasons.

As discussed in the Amendment filed September 12, 2008, the Examiner's reliance on DOWEX MSA-1, as cited in Ito et al., is inappropriate. Specifically, DOWEX MSA-1 has a Gaussian type particle size distribution, and thus is not a uniform particle size porous anion exchange resin, as required by Applicants' claims.

As discussed above, in response to this argument, the Examiner has relied upon the DOWEX MARATHON MSA Product Information sheet. However, the Examiner's reliance on this reference is improper, as DOWEX MARATHON MSA is completely distinct from DOWEX MSA-1.

Applicants enclose the following eight references as evidence that DOWEX MARATHON MSA and DOWEX MSA-1 are distinct.

1. A list of DOWEX products, available at Dow Chemical Company's website (http://www.dow.com/liquidseps/prod/prd_dowx.htm).
2. Technical comments on UPS (Uniform Particle Size) resins, available at Dow Chemical Company's website (http://www.dow.com/liquidseps/prod/ups_gau.htm).
3. Excerpts from a Dow Chemical Company's catalog, "Dow Water Solutions; DOWEX™ Ion Exchange resins; Product Information Catalog".
4. Excerpts from an article by T. Yamamoto, et al., in Proceedings of 1991 JAIF International Conference on Water Chemistry in Nuclear Power Plants, Japan Atomic

Industrial Forum, Inc. (1991).

5. Product information on AMBERLITE™ IRA 900 Cl, available at Rohm and Haas Company's website (http://www.rohmhaas.com/wcm/products/product_detai1.page?product=1123119).
6. Product information on AMBERLITE™ IRA 910 Cl, available at Rohm and Haas Company's website (http://www.rohmhaas.com/wcm/products/product_ detai1.page?product=1123118).
7. Product information on DlAION® PA series, available at DIAION website (http://www.diaion.com/Diaion_Tables/Diaion_AnionTable_R_E.htm).
8. Excerpts from a technical publication by William E. Bornak, "Ion Exchange Deionization for Industrial Users", Tall Oaks Publishing Inc. (2003)

As can be seen in Reference 1, "DOWEX MARATHON MSA" and "DOWEX MSA lC" are categorized as "Strong Base Anion, Type I". However, "DOWEX MARATHON MSA" is indicated as a macroporous "UPS" resin, whereas "DOWEX MSA 1C" is a macroporous resin having a "Gaussian" particle size distribution.

Please note that the term "UPS" means uniform particle size, as explained in Reference 2. In addition, it is known that the letter "C" is often added to a trade name of a DOWEX product (e.g., "DOWEX MSA 1") to identify a product used for condensate polishing (i.e., condensate grade).

According to Reference 3, "DOWEX MARATHON MSA" is categorized as an ion exchange resin for demineralization, whereas "DOWEX MSA lC" is an ion exchange resin for condensate polishing.

Further, the product information for DOWEX™ MSA-1C included in Reference 3 indicates a service flow rate for condensate polishing as 40-150 m/h. On the other hand, that for "DOWEX MARATHON MSA" included in Reference 3 indicates a service flow rate for fast rinse as 5-50 m/h.

Please note that the service flow rate of 5-50 m/h corresponds to a level that is commonly used for production of deionized water.

On the other hand, with regard to a service flow rate of water passing through an ion exchange resin column accommodated in a condensate demineralizer of a nuclear power plant, paragraph [0017] of the present specification describes that a linear flow rate (i.e., service flow

rate) is normally in the range of 50-200 m/h, and typically about 100 m/h. For example, in a condensate polisher (i.e., a condensate demineralizer) of a nuclear power plant in Japan, such as Tokai No. 2 Power Station of the Japan Atomic Power Company, a nominal linear velocity (i.e., a service flow rate) is set at 108 m/h, as described in Reference 4.

In a nuclear power plant, a large amount of highly pure condensate water flows at a high condensate flow rate of approximately 6000 m^3/h within a closed water circulating system. Accordingly, to carry out demineralization in an ideally-downsized condensate polisher, a linear flow rate (i.e., service flow rate) is set at as high a level as approximately 100 m/h. This means that physical stability against a high service flow rate is one of the important factors for selecting an ion exchange resin to be used for condensate polishing.

In view of the foregoing, it is clear that the Examiner's reliance on the DOWEX MARATHON MSA Product Information sheet is inappropriate, as DOWEX MARATHON MSA is distinct from DOWEX MSA 1C. Further, it is clear that "DOWEX MARATHON MSA" cannot be used for treatment of an extremely large amount of condensate water, such as condensate polishing in a nuclear power plant, in contrast to "DOWEX MSA-1".

Thus, one of ordinary skill in the art would not be able to use "DOWEX MARATHON MSA" in place of "DOWEX MSA-1" to carry out the invention described in the Ito et al. reference.

Furthermore, the Ito et al. reference does not teach or suggest use of a macroporous <u>UPS</u> anion exchange resin, since none of the commercially available anion exchange resins raised in column 5, lines 34-41 of the Ito et al. reference are considered to be a macroporous UPS resin ion exchange resin, as can be seen from References 1 and 5-8.

1. Amberlite IRA-900: Reference 5 indicates the particle size uniformity coefficient as ≤ 1.80, whereas that of typical UPS resins is usually indicated as not more than 1.1. Thus, it is clear that Amberlite IRA-900 is an anion exchange resin having Gaussian type particle size distribution, rather than a UPS anion exchange resin.

2. Amberlite IRA-910: Reference 6 indicates the uniformity coefficient as ≤ 1.9. Thus,

Amberlite IRA-9l0 is clearly an anion exchange resin having Gaussian type particle size distribution, rather than a UPS anion exchange resin.

3. DIAION® PA series: Reference 7 indicates the uniformity coefficient as < 1.6. (Please note that the description "> 1.6" appearing in reference 7 is obviously a clerical error, and is correctly indicated as "< 1.6" in the counterpart Japanese website.) Thus, it is clear that each of the DIAION® PA resins corresponds to an anion exchange resin having Gaussian type particle size distribution.

4. DOWEX MSA-1 and MSA-2: Reference 1 clearly indicates DOWEX MSA-l and MSA-2 as "Gaussian" (i.e., having Gaussian type particle size distribution).

5. Lewatit MP500: Table 4-5 of Reference 8 clearly indicates Lewatit MP-500 as "heterodisperse". Also, it is described on page 86, lines 5-8 of Reference 8 that the Gaussian resins are often referred to as heterodisperse, and that the uniform particle size (UPS) resins are often referred to as homodisperse or monodisperse. Therefore, Lewatit MP-500 is not a UPS resin but a Gaussian resin.

Accordingly, the Ito et al. reference does not teach or suggest use of a UPS resin as a rnacroporous anion exchange resin for a mixed bed of the condensate demineralizer. There is no suggestion or motivation for one of ordinary skill in the art to select a <u>UPS</u> resin in the Ito et al. reference.

In conclusion, the Examiner's rejection raised against claims 1 and 3 based on the Ito et al. reference in view of DOWEX MARATHON MSA Product Information Sheet is untenable.

For these reasons, the invention of claims 1 and 3 is clearly patentable over Ito et al.

Conclusion

Therefore, in view of the remarks, it is submitted that the ground of rejection set forth by the Examiner has been overcome, and that the application is in condition for allowance. Such allowance is solicited.

If, after reviewing this Response, the Examiner feels there are any issues remaining which must be resolved before the application can be passed to issue, the Examiner is respectfully requested to contact the undersigned by telephone in order to resolve such issues.

Respectfully submitted,

Takeshi IZUMI et al.

/Amy E. Schmid/
By: 2009.03.12 17:22:59 -04'00'

Amy E. Schmid
Registration No. 55,965
Attorney for Applicants

AES/emj
Washington, D.C. 20005-1503
Telephone (202) 721-8200
Facsimile (202) 721-8250
March 12, 2009

Reference 1

Dow Water Solutions

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Dow Water Solutions

- FILMTEC Membranes
- DOWEX Ion Exchange Resins
  - CADIX System Design Software
  - Products
    - Strong Acid Cation Resins
    - Weak Acid Cation Resin
    - Strong Base Anion Resin, Type I
    - Strong Base Anion Resin, Type II
    - Weak Base Anion Resin
    - Mixed Resin
    - Inert Resin
    - DOWEX Polymeric Adsorbent Resins
    - Fine Mesh Resins
    - Additional DOWEX Ion Exchange Resins
  - Applications
  - Ion Exchange Resins Technical Information
  - Interactive Product Selection Guide
- ADSORBSIA GTO
- Ultrafiltration (UF)
- Electrodeionization (EDI)

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Products

Select any of the following products to view product specifications, product datasheets, case histories, and engineering information where available. For assistance in product selection, please see the Interactive Product Selection Guide.

DOWEX Products by Application

Gel		Macroporous	
UPS	Gaussian	UPS	Gaussian
Strong Acid Cation			
DOWEX MARATHON C	DOWEX HCR-S	DOWEX MARATHON MSC	DOWEX MSC-1 C (H)
DOWEX MARATHON C-10	DOWEX HCR-S/S	DOWEX MONOSPHERE 88	DOWEX 88 MB
DOWEX MONOSPHERE C-350	DOWEX HCR-S/S FF	DOWEX MONOSPHERE 88 (H)	DOWEX 88 MB (H)
DOWEX MONOSPHERE C-400	DOWEX HCR-W2	DOWEX MONOSPHERE MP-525C (H)	DOWEX 88
DOWEX MONOSPHERE 650C (H)	DOWEX HGR-W2	DOWEX MONOSPHERE M-31	DOWEX 88 (H)
DOWEX MONOSPHERE 575C NG (H)	DOWEX HGR NG (H)	DOWEX MONOSPHERE DR-2030	DOWEX M-31
DOWEX N406	DOWEX DR-G8	DOWEX UPCORE Mono MC-575 (H)	
DOWEX G-26 (H)			
DOWEX MONOSPHERE 650C UPW (H)			
DOWEX MONOSPHERE 650C NG (H)			
DOWEX MONOSPHERE C-600 B			
DOWEX MONOSPHERE 575C (H)			
DOWEX MONOSPHERE 545C (H)			
DOWEX MONOSPHERE 545C NG (H)			
DOWEX MONOSPHERE 750C (H)			
DOWEX UPCORE Mono C-600			
DOWEX MONOSPHERE 99Ca/320			
DOWEX			

MONOSPHERE 99Ca/350

DOWEX MONOSPHERE 99K/320

DOWEX MONOSPHERE 99K/350

DOWEX MONOSPHERE 650HXC (H)

DOWEX MONOSPHERE 650HXC NG (H)

DOWEX MARATHON 650C (H)

Weak Acid Cation

DOWEX MAC-3

Strong Base Anion, Type I

DOWEX 1

DOWEX MARATHON A

DOWEX MARATHON A LB

DOWEX MARATHON 11

DOWEX UPCORE Mono A-500

DOWEX UPCORE Mono A-625

DOWEX MONOSPHERE 550A (OH)

DOWEX MONOSPHERE 550A UPW (OH)

DOWEX MONOSPHERE 550A LC NG (OH)

DOWEX MONOSPHERE 700A (OH)

DOWEX 21K XLT

DOWEX MARATHON 550A (OH)

DOWEX SBR-P

DOWEX SBR-P C

DOWEX SBR-C

DOWEX SBR LC NG (OH)

DOWEX 21K 16/20

DOWEX 21K 16/30

DOWEX RPU

DOWEX MARATHON MSA

DOWEX UPCORE Mono MA-600

DOWEX MONOSPHERE MP-725A (OH)

DOWEX MSA-1 C

DOWEX™ TAN-1

Strong Base Anion, Type II

DOWEX MARATHON A2

DOWEX UPCORE Mono A2-500

DOWEX SAR

DOWEX 22

DOWEX MSA-2

Weak Base Anion

DOWEX MONOSPHERE 66

DOWEX MONOSPHERE 77

DOWEX MARATHON WBA

DOWEX 66

DOWEX M-43

DOWEX M4195

XUS 43568.00

DOWEX MARATHON WBA-2

DOWEX UPCORE Mono WB-500

DOWEX BSR-1

Mixed Resins

DOWEX MARATHON MR-3

DOWEX MONOSPHERE MR-3 UPW

DOWEX MONOSPHERE MR-450 UPW

DOWEX MONOSPHERE MR-575 UPW

DOWEX MONOSPHERE MR-575 LC NG

DOWEX MR-3 LC NG

DOWEX MB-40

DOWEX MB-50

DOWEX MB

DOWEX MR-5 LC NG

Inert Resins

DOWEX UPCORE IF-62

DOWEX MONOSPHERE 600BB

DOWEX IF-59

Adsorbents

DOWEX OPTIPORE SD-2

DOWEX OPTIPORE L493

DOWEX OPTIPORE V493

DOWEX OPTIPORE V503

Specialty Resins

Fine Mesh Resins

Additional Products

XUS 43600.00

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Reference 2

Dow Water Solutions

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Dow Water Solutions

- FILMTEC Membranes
- DOWEX Ion Exchange Resins
- ADSORBSIA GTO
- Ultrafiltration (UF)
- Electrodeionization (EDI)

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- Dow Water Solutions Home

UPS (Uniform Particle Size): The Key to Greater Productivity in Ion Exchange

What is UPS? In ion exchange, resin beds that contain beads with the same size particle diameter are called UPS or uniform particle size resins. These resins offer a number of process advantages over conventional Gaussian particle size resin beads. For many years, UPS resins could only be produced by screening conventional Gaussian resins - a cost-prohibitive process. In the 1980s, Dow researchers developed and patented a technology to produce UPS ion exchange resins without a mechanical screening process.

Why is UPS better? While conventional resin beads range in size from 50 to 16 mesh, or 300 to 1200 microns, UPS resins have a much narrower particle size distribution, with 95 percent of the beads within 100 microns of the average particle diameter. UPS technology brings performance advantages such as regeneration efficiency, greater operating capacity, less resin loss, increased resistance to organic fouling and more. In short, UPS delivers greater productivity in ion exchange. Learn more.

Why choose Dow for UPS resins? As the world's first supplier to master UPS technology, Dow continues to lead the industry in providing high-performance UPS ion exchange resins. Dow offers customers UPS ion exchange resins with the greatest uniformity and reliability. And, customers can choose from two product lines that offer distinct performance advantages:

> **DOWEX™ MARATHON™ UPS resins** are designed for regenerable systems to run longer and use less regenerant, providing good quality water at the lowest possible operating cost.
>
> **DOWEX™ MONOSPHERE™ UPS resins** are designed for applications that call for the highest quality water, with good productivity as a secondary requirement.

Advantages of UPS Resins

Less Regeneration Chemical Consumption

Greater Operating Capacity

Better Rinse Efficiency

Reduced Leakage

Less Resin Loss

Lower Pressure Drop

Similar Expansion Characteristics

Increased Organic Fouling Resistance

Advantages of UPS Resins in Mixed Beds

Faster Kinetics

Better Separation

Better Color Differentiation

Higher Physical Integrity

Reduced TOC Leachables

Dow Water Solutions Home : UPS (Uniform Particle Size): The Key to Greater Productivity in Ion Exchange

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Reference 3

Dow
Water Solutions

DOWEX™ Ion Exchange Resins

Product Information Catalog

Form No. 177-01730-1108

DOWEX™ Ion Exchange Resins

2. Demineralization

- DOWEX MARATHON™ C
- DOWEX MARATHON MSC
- DOWEX MARATHON C-10
- DOWEX MAC-3
- DOWEX MARATHON A
- DOWEX MARATHON A LB
- DOWEX MARATHON 11
- DOWEX MARATHON A2
- DOWEX MARATHON MSA
- DOWEX MARATHON WBA
- DOWEX MARATHON WBA-2
- DOWEX MARATHON MR-3
- DOWEX IF-59

Product Information

DOWEX™ MARATHON™ MSA

Uniform Particle Size, High Capacity, Macroporous Strong Base Anion Exchange Resin for Water Demineralization Applications

Product	Type	Matrix	Functional group
DOWEX™ MARATHON™ MSA	Type I strong base anion	Styrene-DVB, macroporous	Quaternary amine

Guaranteed Sales Specifications		Cl^- form
Total exchange capacity, min.	eq/L	1.1
	kgr/ft³ as $CaCO_3$	24.0
Water content	%	56 - 66
Uniformity coefficient, max.		1.1

Typical Physical and Chemical Properties		Cl^- form
Mean particle size†	µm	640 ± 50
Whole beads	%	95 - 100
Total swelling ($Cl^- \rightarrow OH^-$)	%	15
Particle density	g/mL	1.06
Shipping weight	g/L	670
	lbs/ft³	42

Recommended Operating Conditions

• Maximum operating temperature:	
OH^- form	60°C (140°F)
Cl^- form	100°C (212°F)
• pH range	0 - 14
• Bed depth, min.	800 mm (2.6 ft)
• Flow rates:	
Service/fast rinse	5 - 50 m/h (2 - 20 gpm/ft²)
Backwash	See Figure 1
Co-current regeneration/displacement rinse	1 - 10 m/h (0.4 - 4 gpm/ft²)
Counter-current regeneration/displacement rinse	5 - 20 m/h (2 - 8 gpm/ft²)
• Total rinse requirement	5 - 7 Bed volumes
• Regenerant:	
Type	4 - 8% NaOH
Temperature	Ambient or up to 50°C (122°F) for silica removal

† For additional particle size information, please refer to the Particle Size Distribution Cross Reference Chart (Form No. 177-01775).

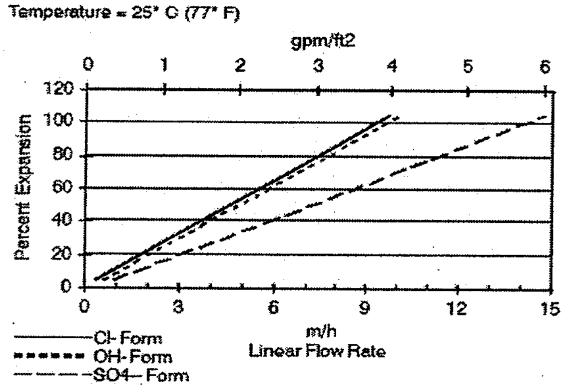
Typical Properties and Applications

DOWEX™ MARATHON™ MSA resin is a uniform particle size macroporous strong base anion resin which has exceptional physical stability, excellent resistance to osmotic shock, and very good organic fouling resistance. It is well suited for use in demineralization of high organic waters, catalysis, and the extraction of heavy metals in the form of complex anions.

Packaging

25 liter bags or 5 cubic foot fiber drums

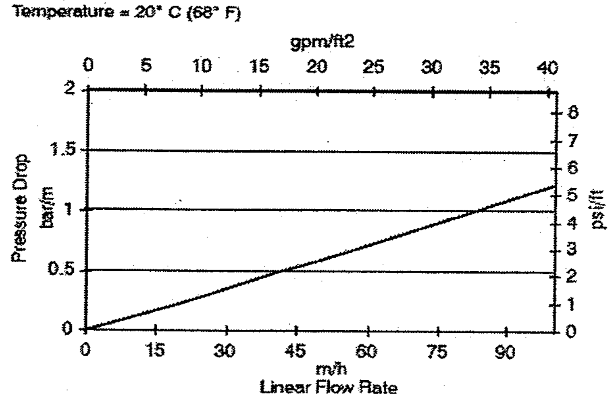
Figure 1. Backwash Expansion Data



For other temperatures use:

$F_T = F_{77°F}\ [1 + 0.008\ (T_{°F} - 77)]$, where F ≡ gpm/ft²
$F_T = F_{25°C}\ [1 + 0.008\ (1.8T_{°C} - 45)]$, where F ≡ m/h

Figure 2. Pressure Drop Data



For other temperatures use:

$P_T = P_{20°C} / (0.026\ T_{°C} + 0.48)$, where P ≡ bar/m
$P_T = P_{68°F} / (0.014\ T_{°F} + 0.05)$, where P ≡ psi/ft

DOWEX™ Ion Exchange Resins
For more information about DOWEX resins, call the Dow Water Solutions business:

North America:	1-800-447-4369
Latin America:	(+55) 11-5188-9222
Europe:	(+32) 3-450-2240
Pacific:	+60 3 7958 3392
Japan:	+813 5460 2100
China:	+86 21 2301 9000

http://www.dowex.com

Warning: Oxidizing agents such as nitric acid attack organic ion exchange resins under certain conditions. This could lead to anything from slight resin degradation to a violent exothermic reaction (explosion). Before using strong oxidizing agents, consult sources knowledgeable in handling such materials.

Form No. 177-01787-1005

DOWEX™ Ion Exchange Resins

3. Condensate Polishing

- DOWEX MONOSPHERE™ 575C (H)
- DOWEX MONOSPHERE 650C (H)
- DOWEX MONOSPHERE 750C (H)
- DOWEX MONOSPHERE MP-525C (H)
- DOWEX MONOSPHERE 550A (OH)
- DOWEX MONOSPHERE 700A (OH)
- DOWEX MONOSPHERE MP-725A (OH)
- DOWEX MONOSPHERE 600BB Inert Resin
- DOWEX HCR-W2
- DOWEX HGR-W2
- DOWEX MSC-1 C (H)
- DOWEX SBR-C
- DOWEX SBR-P C
- DOWEX MSA-1 C

Product Information

DOWEX™ MSA-1 C

A Macroporous Strong Base Anion Exchange Resin for Mixed Bed Demineralization Applications

Product	Type	Matrix	Functional group
DOWEX™ MSA-1 C	Type I strong base anion	Styrene-DVB, macroporous	Quaternary amine

Guaranteed Sales Specifications		Cl^- form
Total exchange capacity, min.	eq/L	1.0
	kgr/ft³ as $CaCO_3$	21.9
Water content	%	56 - 64
Bead size distribution†		
> 1,400 µm, max. (14 mesh)	%	0
> 1,200 µm, max. (16 mesh)	%	2
< 420 µm, max. (40 mesh)	%	2
Whole beads, min.	%	95

Typical Physical and Chemical Properties		Cl^- form
Total swelling ($Cl^- \rightarrow OH^-$)	%	15
Particle density	g/mL	1.06
Shipping weight	g/L	670
	lbs/ft³	42

Recommended Operating Conditions

• Maximum operating temperature	100°C (212°F)
• pH range	0 - 14
• Bed depth, min.	450 mm (1.5 ft)
• Flow rates:	
Service/fast rinse	5 - 50 m/h (2 - 20 gpm/ft²)
Service/condensate polishing	40 - 150 m/h (16 - 60 gpm/ft²)
Backwash	See Figure 1
Regeneration/displacement rinse	1 - 10 m/h (0.4 - 4 gpm /ft²)
• Total rinse requirement	3 - 6 Bed volumes
• Regenerant:	
Type	4 - 8% NaOH
Temperature	Ambient or up to 50°C (122°F) for silica removal

† For additional particle size information, please refer to Particle Size Distribution Cross Reference Chart (Form No. 177-01775).

Typical Properties and Applications

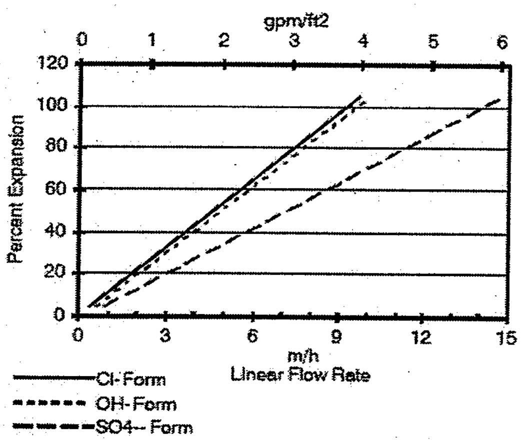
DOWEX™ MSA-1 C strong base anion exchange resin is a condensate grade macroporous resin with exceptional physical stability and resistance to osmotic shock.

Packaging

25 liter bags or 5 cubic feet fiber drums

Figure 1. Backwash Expansion Data

Temperature = 25° C (77° F)



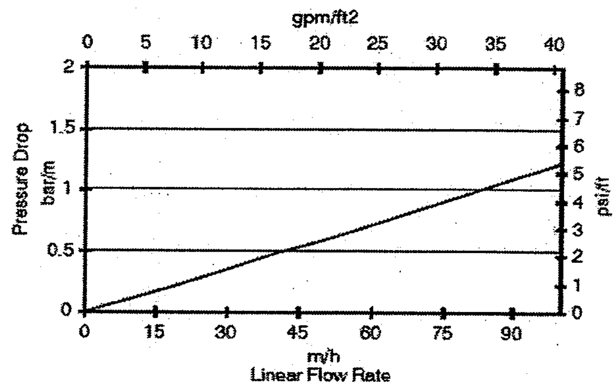
For other temperatures use:

$F_T = F_{77°F}\,[1 + 0.008\,(T_{°F} - 77)]$, where F = gpm/ft^2

$F_T = F_{25°C}\,[1 + 0.008\,(1.8T_{°C} - 45)]$, where F = m/h

Figure 2. Pressure Drop Data

Temperature = 20° C (68° F)



For other temperatures use:

$P_T = P_{20°C} / (0.026\,T_{°C} + 0.48)$, where P = bar/m

$P_T = P_{68°F} / (0.014\,T_{°F} + 0.05)$, where P = psi/ft

DOWEX™ Ion Exchange Resins
For more information about DOWEX resins, call the Dow Liquid Separations business:

North America:	1-800-447-4369
Latin America:	(+55) 11-5188-9222
Europe:	(+32) 3-450-2240
Pacific:	+60 3 7958 3392
Japan:	+813 5460 2100
China:	+86 21 2301 9000

http://www.dowex.com

Form No. 177-01669-904

Reference 4

1991 JAIF International Conference on Water Chemistry in Nuclear Power Plants

—Operational Experience and Strategy for Technical Innovation—

WATER CHEMISTRY '91

PROCEEDINGS

April 22-25, 1991
Fukui City, Japan

Sponsored by : Japan Atomic Industrial Forum, Inc.
Co-sponsored by: Atomic Energy Society of Japan
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Science and Technology Agency

IMPROVING CRUD REMOVAL PERFORMANCE OF DEEP BED TYPE CONDENSATE POLISHER WITH SMALL SIZE ION EXCHANGE RESINS AT BWR PLANT

T.YAMAMOTO , K.HASHIZUME , H.TAKIGUCHI , K.SAKAI
Japan Atomic Power Company
1-1, Shirakata, Tokai-Mura, Naka-Gun, Ibaraki 319-11, Japan
Phone : 0292-82-1211

H.KAWAZU , M.HAGIWARA , Y.OHSHIMA , S.KOSANDA
Ebara Corporation
1-6-27 Kohnan, Minato-Ku, Tokyo 108, Japan
Phone : 03-3458-2111

1. Abstract

In BWR power plants, the principal objective and functions for the installation of the deep bed type condensate polisher is to remove both ionic impurities caused from sea water leakage and suspended impurities called "crud" mainly consisting of metal oxides which are produced from metal corrosion. In considering the reduction of occupational radiation exposure level, it is extremely important to remove the crud effectively. In recent Japanese BWR power plants, condensate pre-filters with powdered ion exchange resins or with hollow fiber membrane have been installed to remove the crud at the upper stream of the condensate polishers. In such plants, the crud removal is conventionally the secondary objective for the condensate polishers.

Since April 1985, the Japan Atomic Power Company had introduced the small mesh size ion exchange resins and then developed a soak regeneration method at Tokai No.2 Power Station, to improve the crud removal performance by using only condensate polishers without any condensate pre-filter, and as a result achieved below 1 ppb as Fe, as expected.

2. Introduction

Table-1 introduces the main specifications of Tokai No.2 Power Station and Figure-1 shows its typical flow diagram. The conventional purpose of the condensate polishers in BWRs was to remove the ionic impurities, caused from sea water leakage in main condenser. However it has become very important to reduce the radiation exposure level to protect operators from radiation.[1] In this regard, it has become primary objective to remove the crud from the condensate water effectively in the condensate purification system and to prevent the crud ingress to reactor. Though the condensate pre-filter was considered to achieve these objectives in recent Japanese nuclear power plants, the installation of additional equipments such pre-filter in existing plants suffered both space and high cost problems. Therefore in Tokai No.2 Power Station, the crud removal by only condensate polisher was chosen.

Table 1:Plant Design Specifications of Tokai No.2 Power Station

1. Type of Reactor	: Boiling Water Reactor
2. Commercial Operation	: November 28, 1978
3. Gross Electric Power (MWe)	: 1,100
4. Condensate Flow Rate (Ton/h)	: 6,435
5. Condensate Purification System	
- Capacity	: Full Flow Polishing
- Type of Polisher	: Deep Bed Type without Any Pre-filter
- Number of Polisher Vessels (DT)	: 9 (+1 as Stand-by)
- Flow Rate per Each Vessel (Normal/Maximum : Ton/h)	: 715/722
- Nominal Linear Velocity (m/h)	: LV=108
- Type of Ion Exchange Resins	: Gel of Nuclear Grade
(Cation Resin)	: (Dowex HCR-W2-H)
(Anion Resin)	: (Dowex SBR-P-C-OH)
- Resin Volume per Each Vessel	: Cation - 4,212 Liters Anion - 2,640 Liters

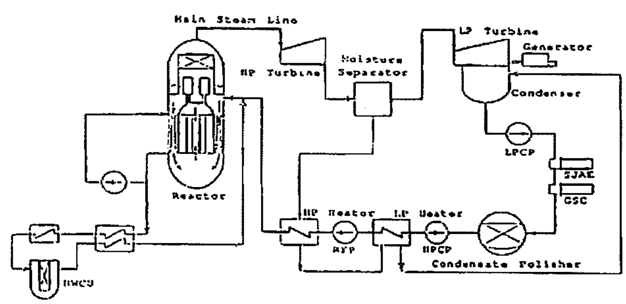

Fig.1 Flow Diagram of Tokai No.2 Power Station

3. Background

1) Introduction of small mesh size ion exchange resins and optimization of regeneration method

The Japan Atomic Power Company has carried out the various researches for development of the crud removal only by condensate polishers without any condensate pre-filters.[2]

Reference 5

AMBERLITE™ IRA900 Cl Industrial grade, macroreticular polystyrene type 1 strong base anion exchange resin

DESCRIPTION:

Rohm and Haas AMBERLITE™ IRA900 Cl resin is a macroreticular polystyrene type 1 strong base anion exchange resin containing quaternary ammonium groups. Due to its macroreticular structure, AMBERLITE™ IRA900 Cl resin is useful in water treatment applications where organic fouling is a concern for strong base, type 1 resins.

Highlighted r
product is av

USED IN:

- Demineralization of boiler feed and process water

ADVANTAGES:

- Excellent kinetics
- Resistance to organic fouling
- High osmotic shock resistance

PROPERTIES:

Typical Properties
These properties are typical but do not constitute specifications.

Physical form	Tan spherical beads
Matrix	Styrene divinylbenzene copolymer
Functional group	Trimethyl ammonium
Ionic form as shipped	Chloride
Total exchange capacity [1]	≥ 1.00 eq/L (Cl^- form)
Moisture holding capacity [1]	58 to 64% (Cl^- form)
Shipping weight	700 g/L
Particle size	
Uniformity coefficient	≤ 1.80
Harmonic mean size	0.650 to 0.820 mm
< 0.300 mm [1]	0.5% max
Reversible swelling	$Cl^- \rightarrow OH^-$: ≤ 25%

[1]Contractural value

Previous product in Ion Exchange Resins for Industrial Water Treatment Next product in Ion Exchanc

Reference 6

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Home > Ion Exchange Resins for Industrial Water Treatment > AMBERLITE™ IRA910 Cl > Product Detail

Imagine the possibilities...

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Highlights

Technical Data

MSDS

AMBERLITE™ IRA910 Cl Industrial grade, strong base, type 2 macroreticular anion exchange resin

DESCRIPTION:

Rohm and Haas AMBERLITE™ IRA910 Cl resin is a strongly basic, type 2, macroreticular anion exchange resin. With its excellent resistance to attrition and osmotic stress, AMBERLITE™ IRA910 Cl resin is used in co-flow regeneration systems requiring very severe specifications: very deep beds, treatment of highly saline solutions.

Highlighted r
product is av

USED IN:

- Boiler feed and process water demineralization; specifically suited for low silica feed waters

ADVANTAGES:

- Higher regeneration efficiency than type 1 strong base anion resins
- Excellent kinetics
- High osmotic shock resistance

PROPERTIES:

Typical Properties
These properties are typical but do not constitute specifications.

Physical form	Pale yellow, opaque spherical beads
Matrix	Macroreticular crosslinked polystyrene
Functional group	Dimethyl ethanol ammonium
Ionic form as shipped	Chloride
Total exchange capacity [1]	≥ 1.00 eq/L (Cl^- form)
Moisture holding capacity [1]	54 to 61% (Cl^- form)
Specific gravity	1.08 to 1.12 (Cl^- form)
Shipping weight	700 g/L
Particle size Uniformity coefficient	≤ 1.9
Harmonic mean size < 0.300 mm [1]	0.53 to 0.80 mm 2.5% max
Maximum reversible swelling	$Cl^- \rightarrow OH^-$: 15%

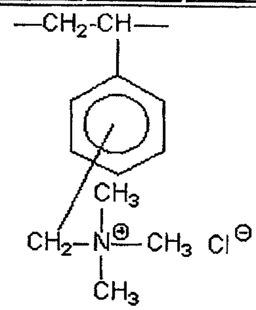
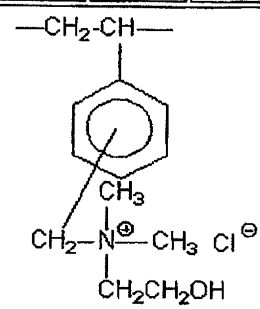
[1]Contractural value

Previous product in Ion Exchange Resins for Industrial Water Treatment Next product in Ion Exchanc

Site Map | Terms and Conditi

Reference 7

DIAION® PA series (Porous type)

Base	type I			type II		
Product	DIAION PA308	DIAION PA312	DIAION PA316	DIAION PA408	DIAION PA412	DIAION PA418
Chemical structure						
Ionic form	Cl					
Appearance index	> 90					
Apparent density (g/L-R)	700	670	680	725	680	690
Ion-exchange capacity (meq/mL)	> 1.0	> 1.2	> 1.3	> 0.9	> 1.1	> 1.3
Water content (%)	57-67	49-55	44-50	57-64	46-52	38-44
Particle size distribution > 1180 μm < 300 μm	< 5 % < 1 %					
Effective size (mm)	> 0.40					
Uniformity coefficient	> 1.6					
Maximum temperature (°C)	< 60 (OH form) < 80 (Cl form)			< 40 (OH form) < 60 (Cl form)		
Crosslikage (%)	4	6	8	4	6	9

三菱化学のイオン交換樹脂･分離精製用樹脂

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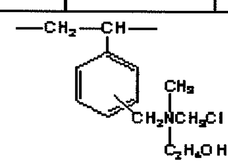
  - 弱酸性陽イオン交換樹脂
  - 強塩基性陰イオン交換樹脂
  - 弱塩基性陰イオン交換樹脂
  - 低臭･低溶出陰イオン交換樹脂
  - 両性イオン交換樹脂
- キレート樹脂
- 合成吸着剤
- クロマト分離用小粒径合成吸着剤
- HPCL充填剤･充填カラム（MCIGEL）

強塩基性陰イオン交換樹脂

ポーラス型 ダイヤイオン PAシリーズ（Ⅱ型）

ポーラス型は多孔性の母体構造を持ち、同一架橋度ではゲル型に比べ若干水分が高く
量が低めですが、膨潤収縮に対する耐久性が高い製品です。水処理において、原水に
含まれ、有機汚染が懸念される場合にも有効です。水処理には通常 PA418が使用され
の脱塩脱色にはPA408が用いられます。
Ⅱ型は、Ⅰ型に比較して塩基度および化学的安定性は多少低下しますが、再生効率は
す。

銘柄一覧表

塩基	ポーラスⅡ型		
製品名	PA408	PA412	PA418
構造			
商品のイオン形	Cl形		
外観指数	95以上		
見掛密度 <参考値> (g/L-R)	710	690	690
中性塩分解容量 (meq/mL-R)	0.9以上	1.1以上	1.3以上
水分（%）	54～64	46～52	38～44
粒度分布* 1,180μm以上 300μm未満	5%以下 1%以下		
有効径 (mm)	0.40以上		
均一係数	1.6以下		
体積変化率 (OH形/Cl形)	1.14	1.13	1.11
真比重	1.09	1.11	1.12

"1.6 or less"

耐用温度(℃)	40以下(OH形) 60以下(Cl形)	
用途	糖液精製脱色	純水製造、アミノ酸分離精製、金属回収、触媒、核酸精製、その他特殊用途

＊PA418は、小粒径部分をカットしたL品が御座います。

三菱化学

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Reference 8

7. The H ion eventually reaches the surface of the bead and leaves the resin.
8. The H ion now randomly diffuses in the bulk water.

It is the presence of the 50% water content within the resin that allows the diffusion of ions into the resin and, once exchanged, allows the exchanged ion to diffuse through the resin, eventually leaving the resin and entering the bulk water.

Microporosity

The visual representation in Figure 4-20 implies that there is a skin on the resin separating the bulk solution outside the bead from the 50% water within the bead. This is not correct. A better representation is shown in Figure 4-21, in which the highly magnified surface of the resin is depicted as the outer part of a tangled skein of polymer strands which constitutes the polymer backbone. Although smooth at the macro level, at the atomic level the surface is quite coarse. The various sized spacings between the strands are of atomic dimensions and freely allow conventionally sized ions to diffuse in and out of the bead. The holes by which ions enter and leave the bead are referred to as *micropores*.

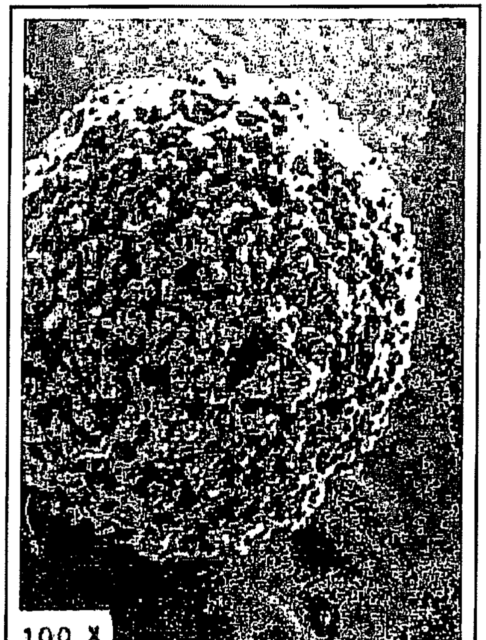

Figure 4-22. Macroreticular Resin, Rohm and Haas Amberlite IRA-938. Photograph courtesy Rohm and Haas. Used with permission

In addition to allowing ions to enter and leave, the micropores of the resin constitutes a continuous path of water between the 100% water solution outside the bead and the 50% water solution within the bead. From an atomic standpoint, there is no "skin" to the resin. And, with a 50% water content, the plastic structure is completely transparent to the movement of ions. This means that ions can move freely within the plastic matrix.

Water of Hydration

The state or condition of the water within the resin is difficult to describe. Even with

50% moisture present, if a resin bead is crushed, droplets of liquid water do not emerge. The resin is chemically described as a "hydrated plastic," indicating that the water is actually part of the structure of the resin. This is similar to the water of crystallization present in many solids. The structure for filter alum, for example, which is used in the clarification of water (Chapter 3), is:

$$\text{filter alum:}\quad Al_2(SO_4)_3(NH_4)_2SO_4{\cdot}24H_2O$$

The 24 H_2O molecules at the end of the structure are called the water of crystallization and they are present in what appear to be dry crystals. As with the resin, when the crystals are crushed, water droplets do not appear; they are part of the structure of the crystal.

The water molecules in the resin must be present as liquid, since ions easily enter and leave the resin and free ions can only exist in liquid water. The individual water molecules are not completely free to move about as they would be in a regular solution. It is believed that some of the water molecules, which are polar, are highly oriented around the fixed and moveable charges of the active groups, which are ionic.

Macroporosity/Macroreticularity

The resins described up to this point are gel resins, indicating that the plastic backbone of the resin has a uniform structure. Gels, whether made of polystyrene, starch, or Jello® are characterized as having a totally homogeneous composition.

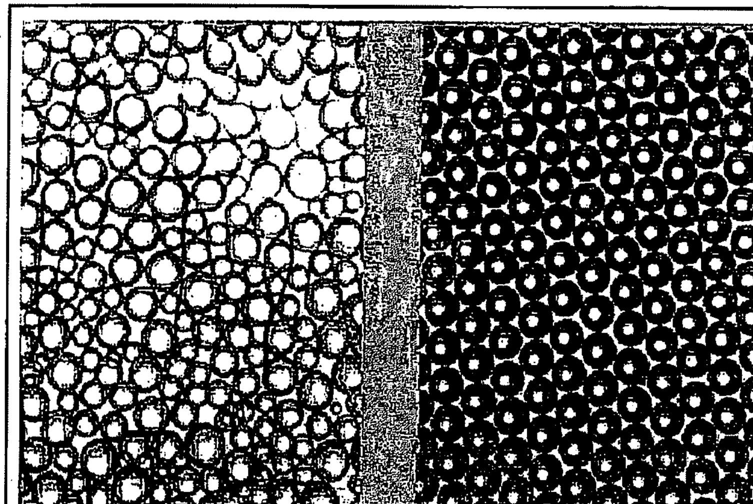

Figure 4-23. Heterodisperse versus monodisperse resins. Photograph courtesy Dow Chemical Company. Used with permission.

Table 4-3
Partial List of Resin Manufacturers

Manufacturer	*Headquarters*	*Trade names*[2]
Aldex	Granby, Quebec, Canada	Aldex®
Dow Chemical Co.	Midland, MI	Dowex®, Marathon®
Rohm and Haas	Philadelphia, PA	Amberlite®, Duolite®, Amberjet®
Ion Exchange India	Ambernath, Maharshtra, India	Indion®
Mitsubishi Chemical	Tokyo, Japan	Diaion®, Relite®
Bayer	Leverküsen, Germany	Lewatit®
Ionac (now part of Bayer)	Birmingham, NJ	Ionac®
ResinTech	West Berlin, NJ	ResinTech®
Thermax	Bombay, India	Tulsion®

[2] The trade names indicated are registered trademarks of the respective companies.

Due to the crosslinking, the ion exchange resins are rigid gels.

It is possible to synthesize the plastic backbone by a process which introduces large holes and channels throughout the bead. These holes and channels are much larger, by orders of magnitude, than the molecular channels through which ions enter and leave the resin. The tiny channels identified above are *micropores*. The large channels are called *macropores*. An example of a macroporous resin is shown in Figure 4-22.

Rohm and Haas invented the original concept of a structured plastic and they termed it *macroreticular*. Other chemical companies use the term *macroporous*. Note this only refers to the structure of the plastic backbone. All the active groups described earlier in this chapter can be attached to the macroporous polymer, once it has been synthesized.

There are several distinct advantages to a macroporous resin:

1. It allows the use of very high DVB levels without sacrificing kinetics (the speed with which ions move in and out of the resin). At high levels of DVB in conventional gel resins, the presence of so many crosslinkers slows down normal ionic movement.
2. The high levels of DVB result in resins of extraordinary physical strength.
3. The macroporosity allows very large ions to enter and leave the resin, ions which would have otherwise been excluded from the micropores.
4. The macroporosity allows some resins to be used in non-aqueous applications, such as catalysis. In non-aqueous solutions the structure of gel resin collapses.

Table 4-4
Partial List of Gel Resins — Heterodisperse

Manufacturer	*Strong Acid*	*Weak Acid*	*Strong Base (Type 1)*	*Weak Base (acrylic)*
Rohm and Haas Amberlite	IR-20 Plus	IRC-86	IRA-402	IRA-68
Dow Dowex	HCR-S	CCR-3[3]	SBR-P	—
Mitsubishi Diaion	SK1B	—	SA12A	WA11
Bayer Lewatit	S-00[4]	CNP-80	M-510[5]	OC 1072
Ionac (Bayer)	C-249	CC	ASB-1-P	
ResinTech	CG-8	WACG	SBG1P	WBACR1

[3] This product is being discontinued and replaced by the macroporous version, Dowex MAC-3.
[4] This product will be replaced by UPS equivalent Lewatit Monoplus S-00 in 2001.

There are some disadvantages to using a macroporous resins:

1. The macroporous resins usually have slightly lower capacity than gels. The open channels within the beads represent "missing" plastic onto which active groups cannot be attached.
2. Macroporous resins usually cost more than their gel counterparts.

The general practice is to use gel resins where ever practicable and resort to macroporous resins only when a compelling factor is present.

Heterodisperse Resins and Uniform Particle Size

Ion-exchange resins were originally made by a batch polymerization process. The starting recipe of monomers, polystyrene and DVB, are organic liquids which will not mix with water. By the use of a large stirrer paddle, the organic solution is dispersed in water. With sufficient agitation, the organic liquid can be broken up into droplets, suspended in the water. When the droplet size approaches the size of the final desired resin beads, the polymerization is initiated. Each droplet polymerizes within itself to become a round plastic bead. Then the various active groups are attached by the series of reactions depicted earlier.

The initial dispersion of the monomer solution into droplets by the paddle produces a range of droplet sizes. The distribution of sizes follows a bell curve, also called a Gaussian or normal curve. In this distribution, most of the resins are of a medium size, but there are some small beads and some large beads. See Figure 4-1 at the beginning of this chapter, which shows typical Gaussian beads,

Table 4-5
Macroreticular/Macroporous Resins — Heterodisperse

Manufacturer	*Strong Acid*	*Weak Acid*	*Strong Base (Type 1)*	*Weak Base*
Rohm and Haas Amberlite	200	IRC-50	IRA-900	IRA-93/94/96
Dow Dowex	MSC-1	MAC-3	MSA-1	MWA
Mitsubishi Diaion	PK228	WK100	PA312	WA30
Bayer Lewatit	SP-12	—	MP-500	MP-64
Ionac (Bayer)	CFP-10		A-641	AFP-329
ResinTech	SACMP	WACMP	SBMP1	WBMP

or the left side of Figure 4-23.

A newer synthesis process uses a continuous extrusion of the liquid monomer solution into a water phase containing the chemicals required for polymerization. The extrusion process produces droplets of identical size. When these droplets are polymerized, the resulting resin beads are also identical in size. This is shown in the right side of Figure 4-23. The Gaussian resins are often referred to as *heterodisperse*, reflecting the range of sizes. The *uniform particle size* (UPS) resins are often referred to as *homodisperse* or *monodisperse*, reflecting the single size of the beads.

There are some major advantages to the use of UPS resins in water treatment:

1. UPS resins allow the use of deep beds for packed bed, counter-current applications (counter-current regeneration will be discussed in Chapter6), greatly improving the quality of the product water in cation/anion systems.
2. UPS resins rinse out more quickly than heterodisperse resins, mostly due to the absence of large beads, which typically take longer to rinse.
3. UPS resins are often of higher physical quality (absence of cracks and other defects) due to the gentler synthesis process.
4. Some UPS resins have a slightly higher capacity than their corresponding heterodisperse equivalents.
5. In mixed beds (Chapter 9), UPS resins give excellent separation during backwash.

At one time, the main disadvantage for UPS resins was higher price, but in recent years prices have dropped considerably. Many installations use UPS resins for conventional co-current primary units due to some of the attributes listed above.

Table 4-6
Uniform Particle Size Resins

Manufacturer	*Strong Acid*	*Strong Base*	*Strong Acid Gel(Type 1)*	*Strong Base Gel (Type 1) Macroporous*
Rohm and Haas Amberjet	1200	4200		
Dow Marathon, Monosphere	C, 650 C	A, 550 A	MSC	MSA
Mitsubishi	USK1B	USA12A		
Bayer Lewatit	Monoplus	Monoplus		
Ionac (Bayer)	S-00	M-500		

UPS resins were originally offered only in gel versions, but now macroporous plastic backbones are also available. It should be pointed out there are two ways to produce a USP product:

1. Synthesis in a reactor which produces monodisperse plastic beads
2. Physical screening of a heterodisperse product to eliminate larger and smaller beads.

Resin Manufacturers

Most of the major manufacturers (Table 4-3) have web sites, which describe their entire product line, as well as providing a direct e-mail link to the marketing departments.

Commercial Products

The large range of commercial products can be confusing. It is helpful to organize the products by plastic type: gel versus macroporous. Then, within each broad category, the products are organized by active group. Table 4-4 lists some gel resins commonly used for standard water treatment. Table 4-5 lists macroporous resins. Table 4-6 lists UPS products.

There are special products for mixed-bed demineralizers, some of which represent combinations from the above tables, and some of which are specially formulated for the application. These will be discussed in Chapter 9. Many manufacturers also offer highly specialized products, such as resins for condensate polishing, nuclear use, food, process, industrial chromatographic applications, and even non-aqueous uses. Highly purified resins are also available for laboratory applications. It's truly astounding how many different commercial and academic areas use ion-exchange resins in addition to industrial water treatment.■